Evaluation of UV atmospheric correction in the presence of absorbing aerosols, and quantification of enhancements provided by multi-angle, polarimetric and oxygen A-band observations

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PACE opens new vistas in aquatic biology…

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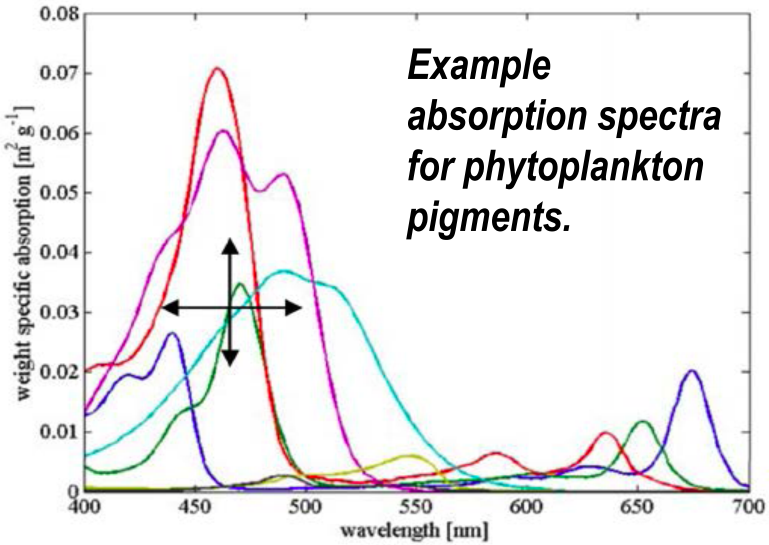
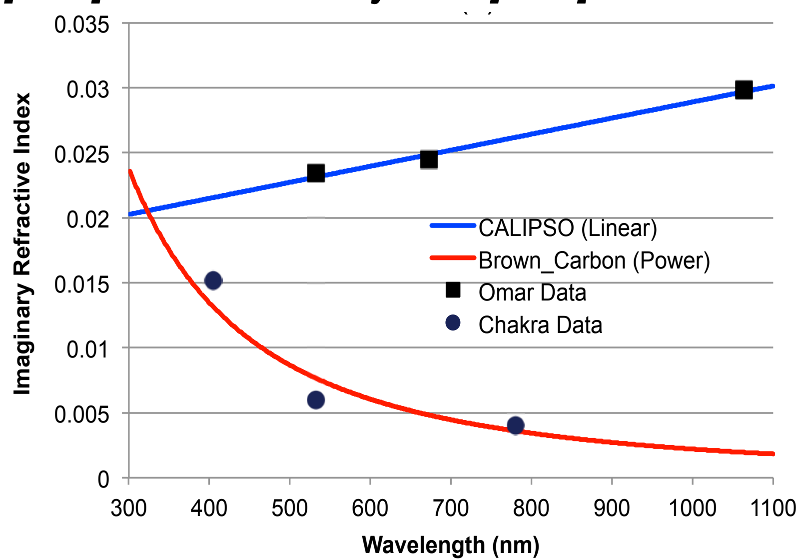
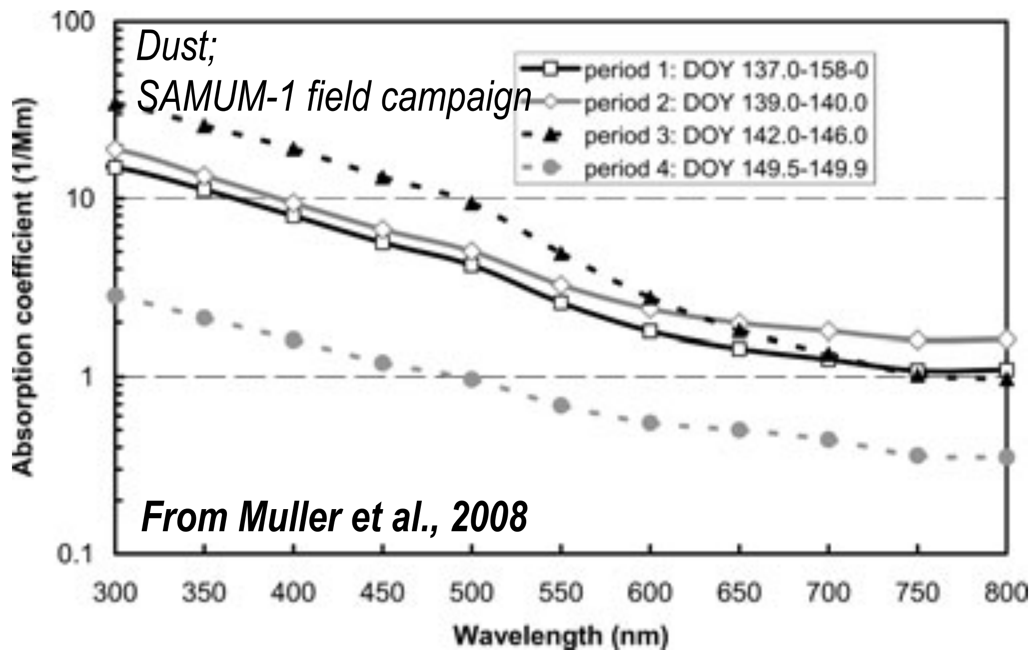


Blue and near-UV spectra from the OCI will measure accessory (non-chlorophyll) pigments, separate chlorophyll and colored dissolved organic matter, and characterize phytoplankton taxonomy.

…**but atmospheric interference makes this challenging**

Extrapolated from data reported by Omar et al. [2005] and Chakrabarty et al. [2010]





What we proposed to do?

- **Objective 1:** Refine the requirements for a PACE imager with combined multiangular, UV to shortwave infrared, oxygen A-band, and polarimetric sensing capabilities for atmospheric correction in presence of absorbing aerosols.
- **Objective 2:** Assess the practicality of the requirements for polarimeter observations in compensating for the effects of absorbing aerosols.
- **Objective 3:** Quantify the added value of the polarimeter to the PACE ocean color spectrometer for simultaneous characterization of mineral dust properties and determination of how ocean ecosystems respond to dust deposition.

Coupled aerosol/surface retrieval code

Model characteristic	JPL code implementation
Forward RT calculation method	Markov Chain + Doubling/Adding (MarCh)
Aerosol size model	Multi-bin, bimodal
Particle shape	Spherical
Refractive index	Mode dependent
Land surface model	Modified RPV + Fresnel microfacet distribution
Ocean surface model	Cox-Munk + bio-optical (in development/testing)
Language	Matlab (for development), C++*
Linearized for optimization	Calculated from Jacobians
Optimization approach	Levenberg-Marquardt

F. Xu, A. B. Davis, S. V. Sanghavi, J. V. Martonchik and D. J. Diner (2012). Linearization of Markov chain formalism for vector radiative transfer in a plane parallel atmosphere/surface system. Appl. Opt. 51, 3491-3507.

F. Xu, A. B. Davis, and R. A. West (2011). Markov chain formalism for vector radiative transfer in plane-parallel atmosphere overlying a surface of bidirectional reflectivity. Opt. Lett. 36, 2083-2085.

F. Xu, A. B. Davis, R. A. West, and L. W. Esposito (2011). Markov chain formalism for polarized light transfer in plane-parallel atmospheres, with numerical comparison to the Monte Carlo method. Opt. Express 19, 946-967.

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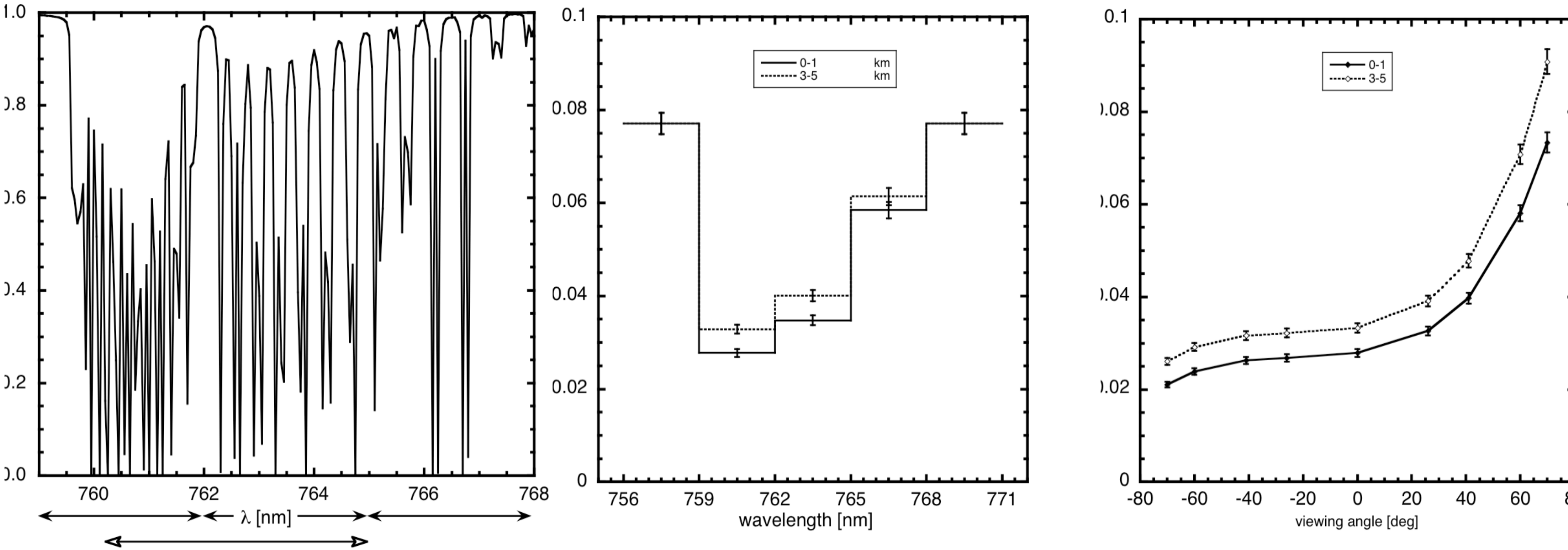
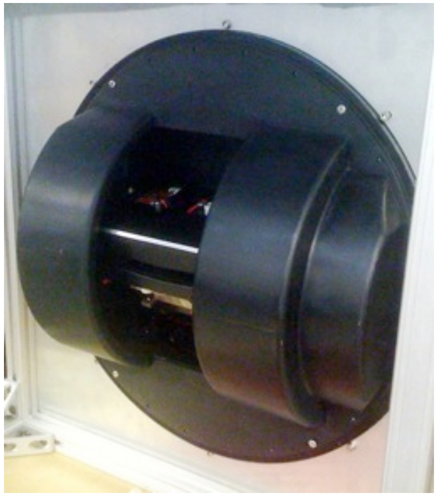
A-band analysis

AC correction requires determining not only the amount but also the height of absorbing aerosols embedded in the background of Rayleigh scattering molecules [Duforêt et al., 2007].



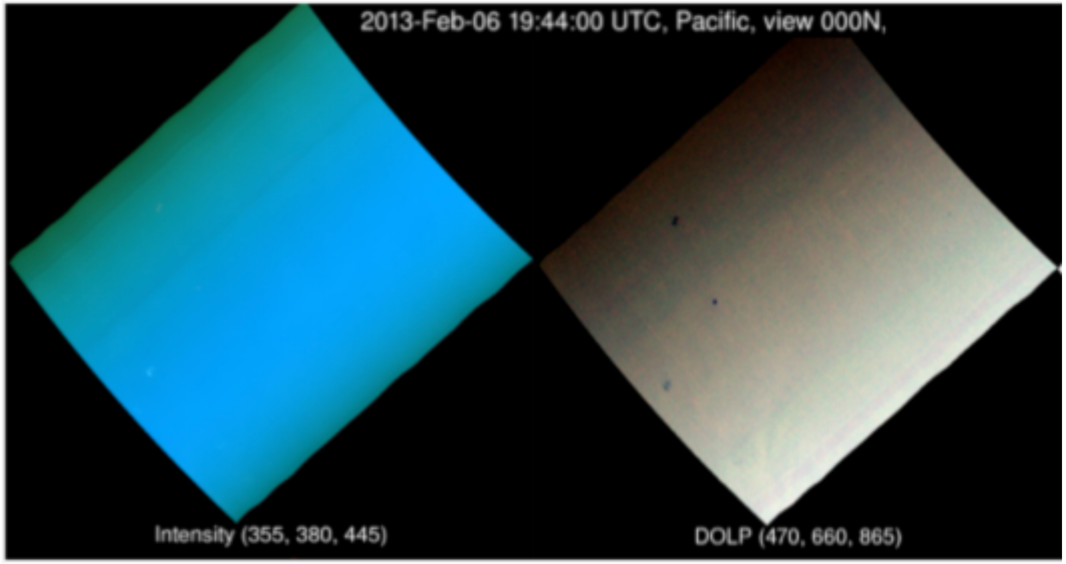
Left: Synthetic reflectivity spectrum at TOA in the O_2 A-band at 0.05 nm resolution, normalized (DOAS-style) to continuum level; spectral coverage by OC hyperspectral sensor (3 pixels) and single "polarimeter" channel are indicated. Middle: Spectral signals (in arbitrary units) at 3 nm resolution for an optically thin dust layer in the 1–2 and 3–5 km zones, assuming the sun is 60º from zenith and nadir viewing. Right: Same as middle panel but for the multi-angle "polarimeter" signal where we see that at the same noise level (assumed to be 3%), the two aerosol layer elevations are easier to distinguish, using error magnitude as a unit of signal distance (in the spirit of the Z-score).

Using AirMSPI to explorer value of polarimeter for PACE



Because AirMSPI has UV bands, polarization, and multi-angle viewing, we can use selected channels to explore the sensitivity of different channel/angle combinations to normalized water leaving radiance (Lwn) and the necessary corrections for atmospheric effects.

Spectral bands	355, 380, 445, 470*, 555, 660*, 865*, 935 nm (*polarized)
Flight altitude	20 km
Multiangle viewing	Between ±67º using single-axis gimbal



AirMSPI data acquired over the USC SeaPRISM AERONET-OC site on the Eureka platform on 6 Feb 2013

How do we connect to larger group?

PACE ocean science requires unprecedented retrieval methods to characterize:

- non-chlorophyll pigments and phytoplankton taxonomy (with UV wavelengths)
- Ecosystems in coastal regions, estuaries, tidal wetlands, and lakes, where water spectra are unlike the open ocean

B. Mitchell, UCSB: Retrieving UV-absorbing mycosporine amino acids, algal proteins, and particle size distributions is needed to specify phytoplankton functional groups and plankton ecosystem structure.

S. Maritorena, UCSB: Dissolved organic matter and absorbing aerosols both absorb in the UV, which may limit the ability to differentiate them.

H. Dierssen, U. Conn: New methods are needed to avoid confusion of NIR backscatter from whitecaps, floating vegetation, and sediments with aerosols.

Multiangle polarimetry distinguishes atmosphere and surface scattering and absorption from the UV-VNIR

→ The polarimeter provides major risk reduction for PACE science